UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

Ref: 8HWM-SM

MEMORANDUM

TO: William Fraser, RPM
Rocky Flats Plant Site

FROM: Susan Griffin, Toxicologist
Superfund Technical Section

SUBJECT: Review of Technical Memorandum #5 (Version 2) - OU2

Per your request, I have reviewed the second version of the document entitled Technical Memorandum #5, Human Health Risk Assessment, Exposure Scenarios, Operable Unit (OU) No. 2. Except for the inclusion of future on and off-site residents and current on-site workers as receptor populations, this document is essentially unchanged from Version 1. I still have serious concerns with a number of the assumptions used in the quantitative exposure assessment calculations. These assumptions, which are detailed below, would significantly underestimate the estimate of risk associated with a reasonable maximum exposure from OU 2.

Exposure Pathways - Section 4

Current-Off-Site Resident (4.5.2.1)

The pathways listed on page 4-9 to be evaluated for current off-site residents should also include ingestion of homegrown vegetables **and fruits** which have been contaminated via uptake of contaminants from soil. The list on page 4-9 includes ingestion of vegetables only which have been contaminated from deposition of particulates. However, both sources of contamination should be evaluated for fruits and vegetables. The rationale provided in the document for not evaluating the uptake source for plants is that metals bind to soil, thus reducing their bioavailability to plants. This is correct, however, reduced bioavailability should not be equated with no bioavailability. Heavy metal uptake into vegetable crops has been well documented (Boon and Soltanpour, 1992). Plant uptake of metals varies depending on factors such as plant type, soil type, soil contaminant concentration, precipitation, etc. Studies have found concentrations of lead ranging up to 1500 ppm in plants, and cadmium ranging up to 35 ppm (Hemphill et al, 1973). This is not an insignificant amount. Hence, both vegetable and fruit uptake of contaminants from soil, as well as deposition of contaminated particulates onto the surface of vegetables and fruits should be evaluated as an exposure pathway to off-site residents.

The pathways on page 4-9 should also include external irradiation from decay of radioactive materials in contaminated soils. As described in Risk Assessment Guidance for Superfund (RAGS), Part A, Chapter 10 (EPA, 1989), external radiation exposure is a concern with radionuclides which emit gamma rays (such as Americium and Plutonium), which are the most penetrating of the emitted radiations.

Future Off-Site Resident (4.5.2.5)

The pathways listed on page 4-17 for the future off-site resident should include ingestion of homegrown vegetables **and fruits** which have been contaminated via uptake of contaminants from soil, as well as from deposition of particulates. The reasoning for this is provided in the paragraph above concerning current off-site residents.

The pathways listed on page 4-17 should also include external irradiation from decay of radioactive materials in contaminated soils. The reasoning is also provided in the above section.

Estimating Chemical Intakes - Section 5.0

General Exposure Assumptions (5.1.1)

On page 5.3 the exposure frequency to soil ingestion and inhalation of particulates was changed from 350 days/year to 290 days/year (for residential) and from 250 days/year to 207 days/year (for occupational) because of information on snow cover. If the information were being used to determine whether or not someone actually went on the site because of the weather, such as in a recreational or trespassing scenario, this assumption would be correct. However, since the residents are expected to live in their housing areas, and the workers are expected to come to work regardless of the weather this assumption is inappropriate. The concept that soil ingestion is limited to outdoor exposure is erroneous. The EPA soil ingestion value is a combination of outdoor soil and indoor dust which can not be divided evenly throughout the day. Tracer element studies have shown that approximately 50% of soil ingestion is from outdoor soil and approximately 50% is from indoor dust, even though the study participants were outdoors only 1.5 hours/day on the average (Stanek and Calebrese, 1992). Unless site-specific information is available on the concentration of contaminants in both outdoor soil and indoor dust, it is assumed that the concentration of contaminants in indoor dust is equal to the concentration in outdoor soil. Therefore the exposure frequency for ingestion of soil should remain at 350 days for residential and 250 days for occupational receptors.

Inhalation Assumptions (5.1.2)

Page 5-4 lists the inhalation exposure frequency for current and future residential receptors as 16 hours/day. This is incorrect. The correct value is 24 hours/day. It is not unreasonable to assume that sensitive members of the receptor population such as infants and elderly people spend the entire day at their housing area.

Page 5-5 is proposing a deposition factor of 25% for inhaled particles. I would recommend that the deposition factor be eliminated, unless appropriate chemical-specific pharmacokinetic evidence can be provided. Although it is recognized that inhaled particles are deposited in different regions of the respiratory system, this preferential deposition is quite variable depending on particle size, particle diameter, chemical properties of the contaminant, etc. In situations where the use of a deposition factor would be appropriate, such as route-to-route extrapolations based on **absorbed** doses, information on the exposure conditions and pharmacokinetics of the contaminant should be evaluated carefully before a deposition factor is selected.

It is generally inappropriate, however, to use a deposition factor in a generic equation for estimating exposure. To obtain an estimate of risk, the intake derived from this calculation is compared to a reference concentration (RfC) of slope factor which is, except for a few cases, based on a **delivered** dose. In other words, the toxicity predicted by the majority of RfC's or slope factors is directly comparable to a given chemical concentration in the inhalation chamber (or occupational setting). It is not directly comparable to the amount of chemical deposited in the pulmonary region or absorbed into the blood stream.

Soil Ingestion Assumptions (5.1.3)

Tech Memo #5 proposes to modify soil intake by using a fraction ingested factor and a bioavailability factor on page 5-6. I suggest that both of these factors be removed.

The purpose of the fraction ingested factor is to modify the amount of soil ingested by a receptor, based on the assumption that a person only spends so much time outdoors, and that soil ingestion is limited to outdoor exposure. The concept that soil ingestion is limited to outdoor exposure, and that the EPA soil ingestion value can be evenly divided throughout the day is erroneous. The 100 mg/day soil ingestion value is a combination of outdoor soil and indoor dust. Tracer element studies have shown that approximately 50% of soil ingestion is from outdoor soil and approximately 50% is from indoor dust, even though the study participants were outdoor only 1.5 hours on the average (Stanek and Calabrese, 1992). Hence, the idea that soil ingestion only occurs outdoors and is proportional to the time spent outdoors is incorrect.

The bioavailability factor assumes that contaminants bind tightly to soil and, when ingested, are not available for absorption across the G.I. tract into the bloodstream. Bioavailability of contaminants from soil in the G.I. tract is an unresolved issue. Not only is bioavailability chemical-specific, but the scientific literature to date suggests that the bioavailability of the few chemicals actually studied is highly variable. Bioavailability is affected not only by the chemical present, but the chemical species, particle size, chemical concentration, soil morphology, and physiological status of the receptor (stomach pH, nutritional status, time between meals, etc.). Perhaps the most extensively studied chemical in terms of bioavailability is lead. A number of animal bioavailability studies using different forms of soil and lead species have been conducted with resulting bioavailabilities ranging from 5 - 40%. Even for a chemical as well studied as lead, it is difficult to recommend a bioavailability factor. Region 8 has, however, used reduced bioavailability factors for contaminants based on site-specific geochemical and geophysical characterization of the chemical form present in the soil and <u>in vivo</u> bioavailability studies in animals. If DOE can provide this type of site-specific data, we will consider the use of a reduced bioavailability factor, However, until DOE provides this evidence or until further research is conducted in this area, it would be extremely difficult to recommend a factor for bioavailability from soil at this time.

Homegrown Produce Ingestion Assumptions (5.1.4)

For each pathway where ingestion of homegrown produce is a concern, **both** fruits and vegetables should be evaluated, and contamination from uptake as well as deposition should be assumed. The reasons for this have been provided above.

Page 5-7 states that 80,000 mg/day is the daily RME intake rate for vegetables. This is correct, however, fruit can also be considered as "homegrown produce". The daily RME intake rate for homegrown fruit is 42,000 mg/day (EPA, 1991a)

Page 5-7 proposes the use of a matrix effect of produce on the bioavailability of ingested contaminants from that produce. This assumption should be removed. Contaminants which are deposited on the surface of produce are not "bound" to the produce. Most of these contaminants can be readily washed off of the produce with water. However, one should not make the assumption that people always wash their produce, because they don't. Therefore, it is reasonable to assume that the contaminants on the surface of the produce are readily available for absorption from the G.I. tract. It's plausible to assume that contaminants which have been taken up from the soil into the plant, are not as readily available for absorption as are contaminants deposited on the surface of the produce. However, the available information on this phenomena is even more scarce than that on the bioavailability of contaminants from soil. Until further research is conducted in this area, it would be extremely difficult to recommend a factor for bioavailability from produce.

Dermal Contact with Soil (5.1.6)

Page 5-8 states that dermal uptake of metals is negligible and is not addressed in human health risk assessments. The second part of this statement is incorrect and does not accurately reflect the text which it references. Dermal uptake of metals is oftentimes insignificant in relation to other pathways of exposure, however EPA will generally address it either in a quantitative or qualitative manner depending on the region and the site-specific circumstances. This statement should be corrected. Region 8's policy has been to address dermal exposure to metals in a qualitative manner in a human health risk assessment.

Page 5-8 assumes an RME surface area of 2,910 cm^2/day for dermal contact with soil for both the residential and occupational receptors. This is incorrect. EPA's Dermal Exposure Assessment: Principles and Applications (EPA, 1992a) and Interim Dermal Risk Assessment Guidance (EPA, 1992b) suggest that a typical or average surface area for dermal exposure to soil (head and hands only, individual wears a long-sleeved shirt and pants) is 2,000 cm^2 and a reasonable upper value (head, hands, forearms, and lower legs, individual wears a short-sleeved shirt and shorts) is 5,300 cm^2. Although an occupational worker on the site may wear a long-sleeved shirt and pants at all times, this is not a reasonable assumption to make for a residential receptor. Both of these values can be explored in the risk assessment, however, to be consistent with the RME concept, the value of 5,300 cm^2 should be used.

Page 5-9 proposes to calculate an absorbed fraction for dermal exposure based on data available in the scientific literature. EPA's Dermal Exposure Assessment: Principles and Applications (EPA, 1992a) provides suggested values for the dermal absorption fraction of several chemicals/classes of chemicals, as well as guidance on calculating an absorbed fraction for chemicals for which no experimental dermal absorption data from soil is available.

Page 5-9 proposes to use a soil adherence factor of 0.5 mg/cm^2. Both of the dermal guidance documents listed above (EPA 1992a, 1992b) recommend a central tendency value for soil adherence of 0.2 mg/cm^2 and an upper value of 1.0 mg/cm^2. To be consistent with the RME concept, the value of 1.0 mg/cm^2 should be used in the risk calculation.

Page 5-9 proposed to use a modifying factor for the fraction of soil contacted. You should be aware that this parameter is not part of the dermal exposure equation provided in RAGS: Part A (EPA, 1989) or the Interim Dermal Risk Assessment Guidance (EPA, 1992b). This factor erroneously assumes that (1) dermal exposure occurs via outdoor soil only and not via indoor dust (similar to the assumption made for the soil ingestion fraction above), and (2) dermal exposure to soil occurs only when you are outdoors (i.e., the soil disappears from your skin when you come indoors). For these reasons, this factor should be removed from the calculation.

Dermal Contact with Surface Water (5.1.7)

The document proposes a water permeability constant of 8.0 E-04 cm/hour. The Interim Dermal Risk Assessment Guidance (EPA, 1992b) provides permeability constants for 200 common organics in water and 13 inorganics. I suggest that these chemical-specific values be used instead of a generic default value.

External Irradiation (5.1.9)

This section proposes to estimate exposure from external irradiation from a method described in EPA's RAGS: Part A (EPA 1989) which is difficult to follow. A somewhat less confusing method is described in EPA RAGS: Part B (EPA 1991b) and may be easier to use.

Tables 5-1 - 5-30

The tables in this section should be revised appropriately to reflect the comments above.

References

Boon, D.Y. and Soltanpour, P.N. (1992). Lead, Cadmium, and Zinc Contamination of Aspen Garden Soils and Vegetation. J. Environ. Qual. 21:82-86.

Hemphill, D.D., Marienfeld, C.J., Reddy, R.S., Heilage, W.D. and Pierce, J.O. (1973). Toxic heavy metals in vegetables and forage grasses in the Missouri Lead Belt. J. Assoc. Off. Anal. Chem. 56:994-998.

Stanek, E.J. and Calabrese, E.J. (1992). Soil ingestion in Children: Outdoor Soil or Indoor Dust? J. Soil Contam. 1(1): 1-28.

U.S. Environmental Protection Agency (1989). Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual. EPA/540/1-89/002.

U.S. Environmental Protection Agency (1991a). Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03

U.S. Environmental Protection Agency (1991b). Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. OSWER Directive 9285.7-01B

U.S. Environmental Protection Agency (1992a). Dermal Exposure Assessment: Principles and Applications. EPA/600/8-91/011B. Office of Health and Environmental Assessment, Washington, DC 20460

U.S. Environmental Protection Agency (1992b). Interim Dermal Risk Assessment Guidance (Draft). Memorandum from James Konz, Toxics Integration Branch, Office of Emergency and Remedial Response, Washington D.C. June 22, 1992